FOWLE ON ATMOSPHERIC OZONE: ITS RELATION TO SOME SOLAR AND TERRESTRIAL PHENOMENA [1]

551.59 : 546.214

By HERBERT H. KIMBALL

This paper gives the results of a research for which a preliminary report was made a year ago, and published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, **33**: 151, 1928. For his observational data he used the solar spectro-bolograms obtained by the Astrophysical Observatory, Smithsonian Institution, at its observing stations at Harqua Hala, Ariz., Montezuma, Chile, Table Mountain, Calif., and Mount Brukkaros, Africa. Bolograms for about 1,000 days were utilized. On many days as many as six bolograms were obtained at an observing station, a number quite sufficient to determine atmospheric transparency at any desired wave length within the limits at which measurements were made.

The region of the spectrum selected for the study was that covered by the Chappuis band, in the yellow and red, between 0.450μ and 0.650μ. While not visible to the eye even under the most favorable circumstances, Fowle concludes that for the amount of ozone present in the atmosphere this band is a more sensitive indicator of changes in atmospheric ozone than the long-wave portion of the Hartley band, in the ultra-violet (wave-length under 0.310μ).

Fowle's determinations and conclusions differ from those given by Dobson in several respects. We quote his summary in full as follows:

SUMMARY

The amount of energy absorbed from the incoming solar radiation by the yellow ozone band has been used to measure the variations in the amount of atmospheric ozone during the years from 1921 to 1928. These observations have been made in both the Northern and the Southern Hemispheres.

The resulting values show a distinct yearly march in both hemispheres. In the Northern Hemisphere the maxima of this march occur between April and May, the minima between August and November; in the Southern Hemisphere the maxima occur between August and September, the minima between April and May. In other words in both hemispheres the maxima occur in the spring, the minima in the autumn.

In the Northern Hemisphere a marked relationship exists between the ozone and the Wolfer sun-spot numbers. The range in the monthly mean values for the ozone numbers is great and between 20×10^{-4} and 100×10^{-4} calories absorbed per cm.^{2} per minute from the incoming solar energy.

In the Southern Hemisphere no such marked relationship is noted, although one may be masked by the small range and corresponding inaccuracy in the values. The range is only from 20×10^{-4} to 50×10^{-4} calories.

It is suggested—and such a suggestion is strengthened by magnetic data—that we are dealing with two layers of ozone. The first is due to ultra-violet light coming from the sun and hence existing over all the stations. The second is assumed to be due to positively electrified particles emitted from definitely disturbed areas of the sun. This second effect reasonably shows a strong correlation with the Wolfer sun-spot numbers. Probably because these positive particles are deflected towards the earth's north pole this layer of ozone is found over the Northern Hemisphere stations only. At sun-spot minimum it is negligible so far as the present measurements indicate.

All the results of the present paper are based on monthly and yearly means. A consideration of the daily values would be another story. The plot published in the preliminary paper was based on daily values for only two years at Table Mountain. The short study then made of the daily values would indicate that what may be said of the connection between many magnetic values and solar disturbances may be said of ozone; that although with monthly and yearly averages, solar spottedness, for example, goes hand in hand with the amount of ozone, yet a day of many spots may pass with no increase of ozone and vice versa.

Our thanks are due to both Dobson and Fowle for their careful work in this difficult field of research. When we appreciate the difficulties attending the measurements they are making it is not surprising that their results and conclusions are not in complete accord. Both, however, have contributed materially toward the final solution of a question of great interest and importance to meteorologists.

[1] Fowle, Frederick E. Smith. Misc. Coll., 81: No. 11. 1929.

SEVERE WINTER IN EUROPE, 1928–29

551.524 (4)

By CHARLES F. BROOKS and N. H. BANGS

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The stormy conditions, so prevalent during November (see Bulletin Amer. Met'l Soc. for December, 1928, pp. 206–207) over northwestern Europe, continued for the most part during December, culminating in a severe storm in the last week of the month, centered over the eastern North Atlantic and Scandinavia. Westerly gales caused by this disturbance brought high tides and floods along the Belgian lowlands, inundating districts that were just emerging from the floods of the previous month. Germany experienced the most severe fog in recent years, and Russia [U. S. S. R.] reported serious floods along the Neva from the melting snows. No particularly low temperatures were reported.

Conditions changed decidedly with the advent of 1929. By January 4 pressure had increased to 1040 mb. (30.71 in.) over central Europe, and an area of low pressure remained stationary over the Mediterranean.[1] This pressure distribution brought cold northerly winds to France and heavy falls of snow even to the Mediterranean coast, Marseilles reporting a fall of 6 inches. In Italy heavy rains caused floods. From then until the middle of the month pressure tended to remain high over Europe. At times there was a curious northwest-southeast trend to the area of high pressure, with one center in the vicinity of Iceland and the other over Poland. The tendency for the pressure to remain high over Iceland was one of the remarkable characteristics of January, 1929, for only once before, in 1846, has pressure averaged as high over Iceland as in the month under discussion.[2] About the 13th of the month a very severe storm, center 980 mb. (28.94 in.), appeared over Russia, and westerly gales and warmer weather prevailed. Toward the end of the month, while a low-pressure area of extraordinary depth (948 mb., under 28.00 in.) and extent developed and remained over the northwestern Atlantic (see Bulletin Amer. Met'l Soc. for January, 1929, pp. 52–53), pressure began to increase to the north and northeast of Europe, one HIGH, 1045 mb., (30.86 in.) being centered in the vicinity of Spitzbergen, and the other, 1056 mb. (31.18 in.) over eastern Russia.

[1] Information from daily "Chart of Weather in the Northern Hemisphere." Air Ministry (British) Meteorological Office, London.

[2] Cf. Dr. C. E. P. Brooks, in the Meteorological Magazine for February, 1929.

By the 29th the Russia HIGH, laying down a deep snow-blanket as it came, had advanced southwestward and a LOW developed over the eastern Mediterranean. From then on this type of pressure distribution of HIGH in central or north Europe, and LOW over the Mediterranean maintained itself, with a snow-cold-more snow-continued-cold flywheel, without a real break until February 22.[3] The pressure at the center of the HIGH rarely fell below 1035 mb. (30.56 in.) and was constantly replenished by a further influx of cold air from Siberia. The cold air was not deep enough to affect the high Alps, where sunny, comfortable weather prevailed.

The results of such a distribution have filled the pages of the newspapers with countless stories of record low temperatures, tremendous snowfalls, and unprecedented hardship and suffering. The lowest temperatures occurred during the second week of February when the pressure was the highest. Some of the temperatures quoted in the press were: −67° F. at Ivanov-Voznesensk, northeast of Moscow (the previous low for this district being about −50° F.); −40° F. near Vilna in Poland; −31° F. to −49° F. in Silesia; −24° F. at Belgrade; −21° F. at Vienna, −18° F. at Belfort, −15° F. in Berlin. This is the lowest official temperature ever recorded in Berlin. The official records were mild compared with the accounts of hardship, suffering, and death. From the Baltic, where over 40 ships with 1,400 passengers were frozen fast in the ice, to the bread lines of Vienna, and to the still more horrible tales of the wolf-infested villages of the Balkans, was spread a long train of human misery.

The heaviest snowfall occurred apparently in southeastern Europe along the northern border of the Mediterranean LOW, where the warm, moisture-laden air was forced to rise above the cold surface air from the northern HIGH. Three feet of snow fell on Constantinople during the week ending February 9; and the Simplon express was buried for 11 days in a snowdrift in the Balkans. And now come the floods.

Swedish meteorologists, said a news cable, ascribed the severely cold weather to an unusually warm Gulf Stream, presumably the Gulf Stream drift in the Norwegian Sea, which was said to be 5° C. above normal. This explanation harked back doubtless to Dr. J. W. Sandström's paper on the influence of the Gulf Stream on the winter temperature in Europe, published in the Meteorologische Zeitschrift two years ago.[4]

In this paper, Doctor Sandström shows, inter alia, how strong southwesterly winds and large plus departures of temperature in the Lofoten Islands of Northwest Norway, in winter attend cold weather over all but the extreme northwest of Europe, as was the case this year, and he ascribes to the temperature of the Gulf Stream drift near by the primary rôle in this situation. He offers no reasons why the Gulf Stream drift should be considered primary, however, and so it seems difficult to indorse this explanation which appeals so strongly to the imagination and which suggests a Gulf Stream basis for long-range forecasts of European winter temperatures.

How these southwest winds and a warm Gulf Stream make Europe cold is ingeniously explained as a result of the deflective effect of the earth's rotation. The strong southwesterly wind along the coast of Norway, between the warm air at sea and the cold over the continent, is the outflowing wind, from the accumulation of air over the continent, that has been deflected to the right. The southwest wind by virtue of this deflection now exerts an eastward pressure on the cold air over the continent and holds it in check causing it to pile up thereby increasing and continuing the cold weather of the interior. This explanation, based on Doctor Sandström's observations in northern Sweden, showed also why such heavy snows occurred while the cold air was held in check. The western front of the cold air mass is so steep and rises so high that the oceanic winds flowing up and over are cooled rapidly and at low temperatures, therefore, depositing abundant snow. The mechanics of the winter of 1923–24, which was very cold and snowy in Sweden and elsewhere in Europe, were discussed in some detail as an example.

While there can be no question that the action just described attends cold weather in Europe, it is difficult to ascribe its origin simply to the warm, or Gulf Stream, element. The accumulation of cold air over the continent is equally and coincidently involved. This massing of the cold air, it is true, is derived from the expanded air over the warm oceanic waters, perhaps chiefly the Gulf Stream drift of the North Atlantic. However, the way the pressure in the extreme northeastern Atlantic and over North Europe rose as the deep LOW formed in the northwestern Atlantic late in January, 1929, is strongly suggestive that the air leaving the northwestern Atlantic as the LOW formed accumulated in large measure far to the northeast and was essentially responsible for the subsequent southward and southwestward spread of cold air that initiated the Euopean cold period. Lieut. Commander E. H. Smith's observation of a 5° C. plus departure of sea temperature over a large area in the northwestern Atlantic in the early fall[5] may have favored some of the low pressure in this region later. Thus it does not appear that the high ocean temperatures in the northeastern Atlantic were more than a minor cause of this cold spell. In any event, it would be hard to explain why, if such ocean temperatures, which do not change rapidly, were primarily responsible, the cold weather should have come on rather suddenly and not been more the rule earlier in the winter. Furthermore, the lowness of pressure over the Mediterranean and, late in winter, the advance of a great HIGH from Northeast Greenland, and perhaps from Alaska, to a central position over Europe March 1 and 2, indicate other important contributing factors to the cold winter.

The periodic recurrence of cold winters at 100-year intervals, just nine times the sunspot period, was noted by H. Memery, of Bordeaux, and the likelihood of an extremely cold winter at this time and of a moderately cold one next winter was indicated at this time of waning sunspots.[6] The simultaneous occurrence of a cold winter in the interior and west of North America in positions corresponding to those of Europe may be significant of a general control such as solar heat rather than of a more local one of Atlantic Ocean temperatures, though the latter may be a feature secondary to the effect of the high solar activity of the past summer.

The temperatures that occurred in Europe were not extraordinarily low considering the latitude. Weather equally cold and persistent, but less severe on the people

[3] Weather maps for Feb. 11 and 13, isotherms for Feb. 13, and temperature change maps for Feb. 10, 11 and 13, 1929, over Europe, with discussion by F. Honoré, are published in L'Illustration, Paris, Mar. 2, 1929, p. 208 and 209.

[4] J. W. Sandström, Über den Einfluss des Golfstromes auf die Wintertemperatur in Europa. *Met. Zeits.*, Nov., 1926, vol. 43, pp. 401–411, 47 figs. (Summarized by A. Walters in Met'l Mag., Apr., 1928, vol. 63, pp. 61–63, fig.)

[5] Science Service news reports of the *Marion* expedition, July to September, 1928.

[6] Cf. note by C. F. B. in MONTHLY WEATHER REVIEW October, 1928, 56: 417.

because it was less extraordinary, occurred in corresponding latitudes in the interior of North America this winter. The oceanic effect with the prevailing westerly winds is so strong in Europe in a normal winter that a change to continental conditions with easterly winds is striking. The usual position of the axis of high pressure in winter in Europe is only a little to the north of the Mediterranean, and in a latitude where severe cold does not usually develop. This winter, however, the axis of high pressure was about 10 degrees of latitude farther north, bringing extreme continental weather over central and northern Europe in consequence.

THE STEAMSHIP "METEOR" SURVEY OF THE TROPICAL AND SOUTH ATLANTIC OCEAN

551.46.065 (261.5)

Preliminary Report [1]

SUMMARY OF METEOROLOGICAL PORTION [2]

By CHARLES F. BROOKS

The comprehensive 2-year oceanographic and meteorological expedition of the German gunboat *Meteor* [3] to the little-known tropical and South Atlantic Ocean grew out of the late Dr. Alfred Merz's desire to test and develop his new theory of oceanic circulation. Doctor Merz's plans were so well laid that, in spite of his most unfortunate and untimely death early in the expedition, the other scientists, under the leadership of Capt. F. Spiess, were able to complete the survey as projected. Descriptions of equipment, methods, and preliminary results, and the narrative account published during the progress of the work early provided much valuable information, that was helpful, for example, for the program of the *Carnegie*, which set sail on its 3-year cruise less than a year after the *Meteor* returned. This review will take up, first, a few of the outstanding features brought out in the narrative, then, the special investigations of evaporation, meteorology of the surface layer, and aerology.

NARRATIVE OF THE EXPEDITION

After a month's trial trip followed by two months in port making changes, the expedition sailed from Wilhelmshavn in April, 1925, and enjoyed an introductory profile across the zones en route to Buenos Aires. The first 5 of the 14 crossings of the Atlantic (see fig. 1) were between the subtropical high-pressure belt and the south polar region, a stretch of ocean that gave the expedition a full measure of its proverbial storminess in winter and spring. The summer weather, while the expedition was in the highest latitudes, was exceptionally favorable, however. Once the ship found itself in the rather quiet center of a fairly strong cyclone for 10 hours, and the observers succeeded in making a kite flight. In latitudes about 60° and higher, beyond the poleward boundary of the westerlies, the flights showed pronounced surface inversions of temperature.

The SE. trade was found to be a cold-air body, that with a sharp top rises from a shallow sheet at the African coast and steeply falls off at a varying distance from the American coast. Apparently this western limit is in a standing wavelike motion, which for the South American coast area has the same significance as the polar front for the west-wind zone. On Profile VII, latitude 22° mostly, the clouds were regular St. Cu. at 1,400 meters and above these, at the height of the temperature inversion, many kite flights showed a 6° to 16° C. rise in air temperature.

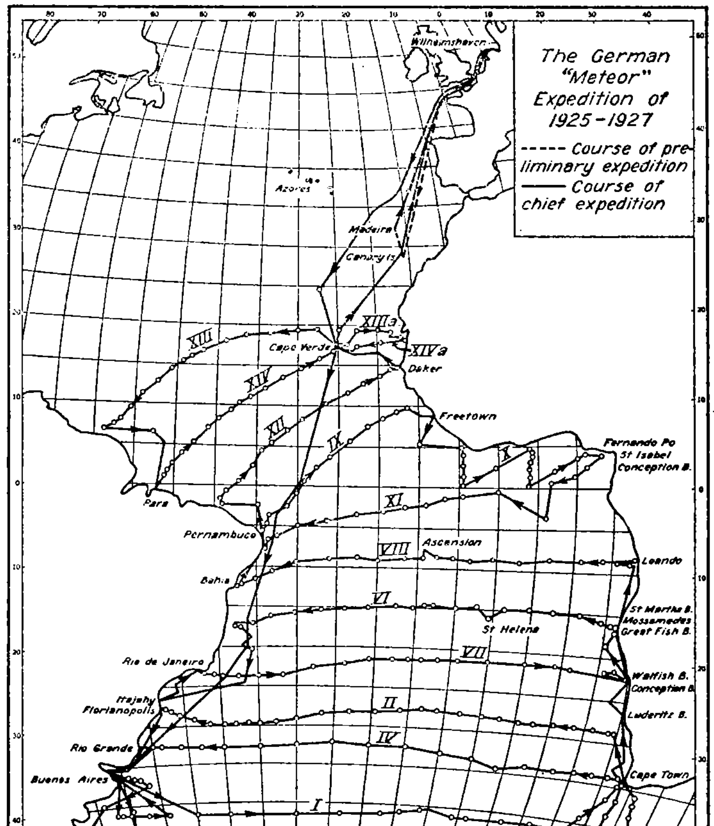

FIGURE 1.—Routes and stations of the *Meteor* expedition, 1925-1927

In the quiet weather near the African coast there was a cold-air sheet only 20 meters deep over the Benguela current. Fog was frequent there, being especially dense and wet where the temperature was lowest, 12° C. near Luderitz Bay (lat. 27). Nearer the Equator, to latitude 9, cool weather with clear skies and light SW. winds was typical along the coast.

The NE. trade, which was investigated in the same season a year later, was found to be stronger but less

[1] Berichte der Deutschen Atlantischen Expedition, I–IV. By F. Spiess, G. Wüst A. Schumacher, E. Hentschel, Otto Pratje, Freiherr von Recum, H. Wattenberg, J. Reger, E. Kuhlbrodt, C. W. Correns, A. Defant, G. Böhnecke, K. Quasebarth. Zeitschr. d. Gesellschaft für Erdkunde zu Berlin. 1926, p. 1–77, 209–272; 1927, p. 81–169, 251–338; photos, maps, diagrams.

Festsitzung zur Begrüssung der Expedition am 24. Juni 1927 veranstalted von der Notgemeinschaft der Deutschen Wissenschaft und der Gesellschaft für Erdunde zu Berlin. By L. Diels, F. Spiess, A. Defant, and F. Schmidt-Ott.

Cf. also the briefer account: Die deutsche allantische Expedition auf dem Vermessungs- und Forschungschiff *Meteor*. By Spiess, v. Recum, Schumacher, and Kuhlbrodt. An. d. Hydr. u. Mar. Met., 1926, 54: 73–94, 393–399, and Köppen-Beiheft, 57–64; 1927, 55: [169], 245–248, photos, maps, diagrams.

NOTE.—"Die Meteor-Fahrt," by Capt. F. Spiess, a comprehensive popular book on the *Meteor* expedition, was published in Berlin in the autumn of 1928, by Dietrich Reimer (Ernst Bohsen); it contains 376 pages, 420 photographs, 34 diagrams, and 4 maps, including a large general map of the voyages.

[2] Presented in brief before the American Meteorological Society at Washington, D. C., Apr. 28, 1928.

[3] Steamship and auxiliary sails: Displacement 1,200 tons, length 75 meters, draft 4 meters, speed 9 knots, cruising radius 6,000 sea miles, crew 133.